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Power Density in Proximity to Radiating Antennas

SCANTER 5000 and 6000 Radar Series

CM: EDM RELEASE CONTROLLED TLM

Record of Changes

CR/CO	Description	Rev	Date
	Pre-release	1A	2010-12-06
	Review by MIA, MDP, CTH & JCP	A	See first page

Contents

1 INTRODUCTION

Terma has in resent years been successful in the development of novel receiver and processing technology, reducing the required transmitter power for a given radar performance. This substantially reduces the microwave radiation when compared to what was possible just a few years ago. However, there is an increasing concern in the public about radiation from microwave sources. This document was therefore made to summarize the results from an analysis of the incident microwave power levels (safety levels) present in the vicinity of SCANTER 5000 and 6000 series radar systems.

All restricted data has been omitted and the document may therefore be released to third parties on a need to know basis (as decided by end users of the radar systems).

Two different safety levels, one for the general public and one for occupational exposure, are defined in guidelines from the International Commission of Non-Ionizing Radiation Protection, ICNIRP [1]. The ICNIRP guidelines have been used throughout the analysis.

The main conclusions in relation to SCANTER 5000 and 6000 series radars using any of the Terma Compact (CO) or High Gain (HG) antennas are:

- The ICNIRP recommendations for general public and occupational staff are met for all locations beyond 1.5m in the horizontal plane and/or 0.25m above/below the antenna.
- For additional safety, SCANTER 5000 and 6000 series transmitters are closed down when antenna rotation is stopped. However, transmission into a stopped antenna can be tolerated without violating the ICNIRP recommendations for general public, for all locations 1 meter or further below the antenna or at any position beyond 7 meters horizontal distance.
- Microwave radiation is only emitted from the antenna system and not from any other part of the SCANTER 5000 and 6000 radar system.

The antenna will typically be elevated at least 30 meters above ground levels when the SCANTER 5000 and 6000 radar series is used for land based applications. In such case, the microwave power exposure at ground level was calculated to be a factor of 10000 or more below the ICNIRP recommendations for general pubic.

2 REFERENCED DOCUMENTATION

[1] International Commission of Non-Ionizing Radiation Protection. Guidelines for Limiting Exposure to time Varying Electrical, Magnetic and Electromagnetic Fields (Up to 300 GHz). *Health Physics 74, 74(No.4):494-522, April 1988.*

3 THE SCANTER 5000 AND 6000 SERIES CONCEPT

SCANTER 5000 and 6000 series is a coherent radar system providing Surface Surveillance. Depending on the application, the system comprises a 50W peak power Solid State Power Amplifier (SSPA) or a 200W peak power SSPA. The duty cycle of both SSPA is maximum 25%.

The transmission frequencies are within the 9.00GHz to 9.50GHz band.

The 200W SSPA, giving highest transmitted power, was assumed present for the analysis referred by this document.

Energy transmitted can be varied depending on operational needs. The highest possible energy has been assumed for the analysis. For the average power analysis 50W is applied corresponding to running the 200W SSPA at maximum duty cycle. For the peak power analysis, 200W is applied.

The analysis is based on antennas of the Compact (CO) or High Gain (HG) antenna product families. All antennas have been analyzed at the centre frequency, 9.250GHz.

For each of two antenna product families the following antenna variants exist:

Compact antennas:
7’ CO-HP-F-31, 12’ CO-HP-34 and 18’ CO-HP-F-35.

High Gain antennas:
18’ HG-HP/CP-F-37, 18’ HG-HP/CP-C/I-36, 21' HG-HP/CP-F-38 and 21’ HG-HP/CP-C/I-37.

The generation of microwave energy and its transmission to the antenna is confined within an unbroken metal enclosure. Therefore, microwave power is not emitted from any parts of the SCANTER 5000 and 6000 radar system, except the antennas.

Transmitters are automatically shut down when the antenna rotation is stopped.

4 POWER DENSITIES

Measurement of radiation levels from radar systems is a specialized task and radiation levels are therefore often determined theoretically using the radar equation and assuming the radar to maintain its far-field antenna gain at all distances from the antenna. However, with the large aperture antennas used in the SCANTER radar systems, results from this method may be misleading.

The difference between the simple radar equation and the formulation used by Terma is a number of extensions that allow for modeling of the exact location, the orientation and the type of the transmitting antenna(s). In particular, the formulation allows for careful modeling of the near-field characteristics of a radiating antenna. These near-field characteristics are important as the spreading of the microwave power in the vicinity of the antenna is quite different from the characteristics at large distances from the antenna (in the far-field). Failure to include the near-field characteristics may lead to over-estimated power densities within the antenna main beam and to underestimated incident power densities outside the antenna main beam.

In addition, the surroundings, which may cause so-called multi-path propagation, must be considered. Reference levels stated by the ICNIRP guidelines include these necessary safety factors to allow for such effects.

The amount of incident power in any position in the surroundings of the microwave source is measured in Watts per m^2.

According to the ICNIRP guideline, the limit for the incident power density level for the general public is $10W/m^2$ (= $0dBm/cm^2$) in the frequency band from 2-300GHz and over any 6 minute period. The SCANTER 5000 and 6000 series radars operate within this frequency range.

The corresponding level for occupational exposure is $50\ W/m^2$ (= $7dBm/cm^2$).

Furthermore, the ICNIRP guidelines states that the peak power density shall not exceed the average power density by a factor of more than 1000. I.e. a peak incident power level of $10kW/m^2$ (= $30dBm/cm^2$) for the general public and $50kW/m^2$ (= $37dBm/cm^2$) for occupational exposure.

5 RESULTS

5.1 Power density contours

The analysis of incident power density is based on a formulation similar to the radar equation. Each antenna is described in terms of its aperture distribution, which allow for computation of its near-field characteristics.

Average as well as peak power results are presented. The worst of the two are used for determining the safety distance required to comply with the ICNIRP recommendations.

Allowance for production tolerances has been made.

In Figure 1 and Figure 2 the results corresponding to the average power limit for rotating antennas, i.e. the $10W/m^2$ (= $0dBm/cm^2$) limit as recommended by ICNIRP for the general public, are shown for each of the two antenna product families Compact (CO) and High Gain (HG).

Figure 3 shows different levels of iso power density contours for the 18' HG-HP/CP-I-36 antenna system. When considering an antenna located 30 meters above ground level this antenna system has the highest power densities at ground level.

In Figure 4and Figure 5 the results corresponding to a power density of 100W/m2 (= 10dBm/cm2) are shown. This power density level is 100 times less than the peak power limit recommended by ICNIRP for the general public. The power density of 100W/m2 (= 10dBm/cm2) is shown for each of the two antenna product families, Compact (CO) and High Gain (HG). As the antenna rotation can be extremely limited during the short transmission time of the radar pulse, the antenna is assumed non-rotating.

The antenna aperture is located in origo, i.e. with a horizontal distance of zero. The aperture is located inside the antenna dome.

5.1.1 Average power limitations

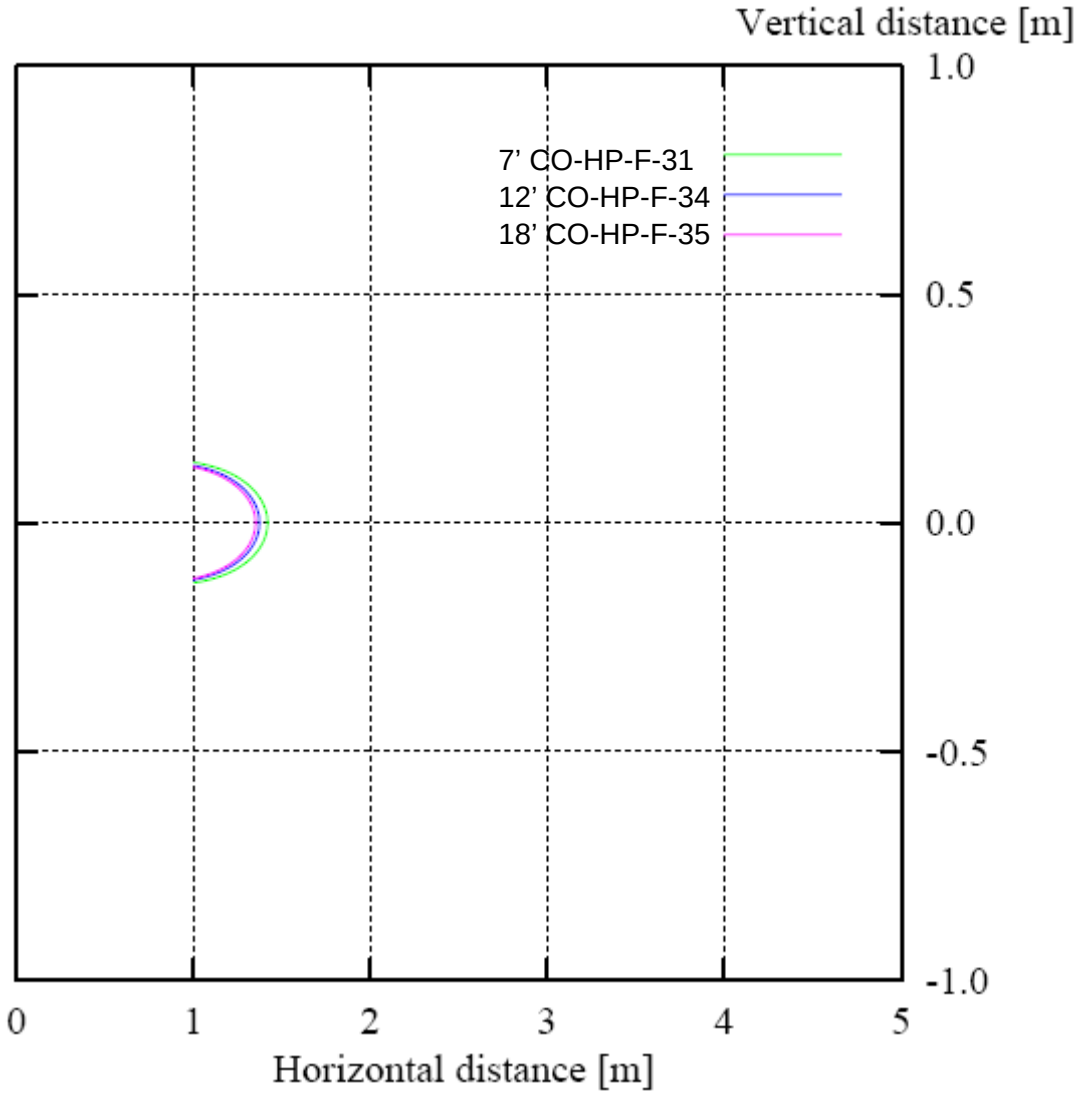

Figure 1 Safety distances for Compact antennas, 50W average power, rotating

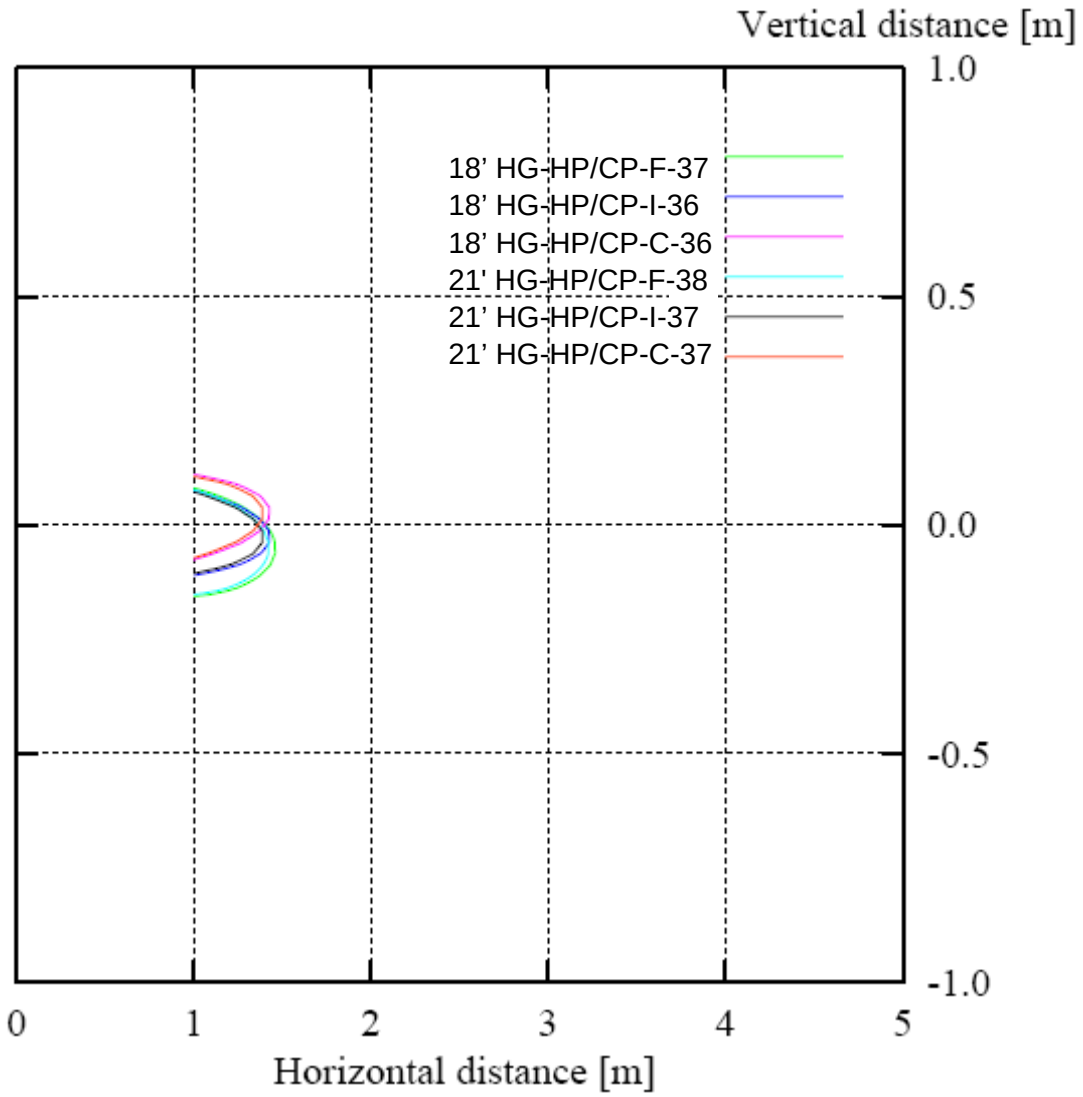

Figure 2 Safety distances for High Gain antennas, 50W average power, rotating

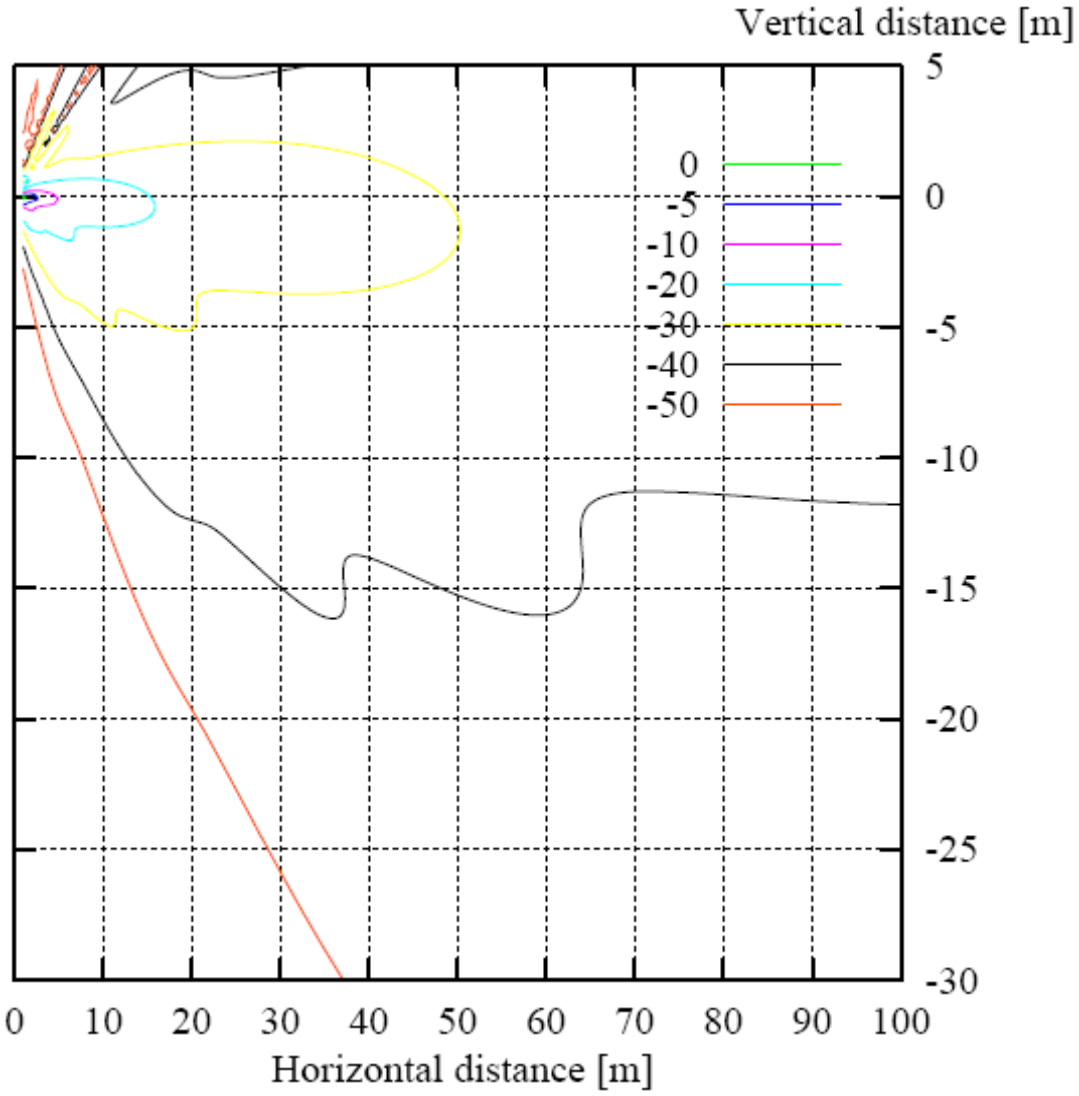

Figure 3 Power densities in units of dBm/cm^2 for 18' HG-HP/CP-I-36, 50W average power, rotating

5.1.2 Peak power limitations

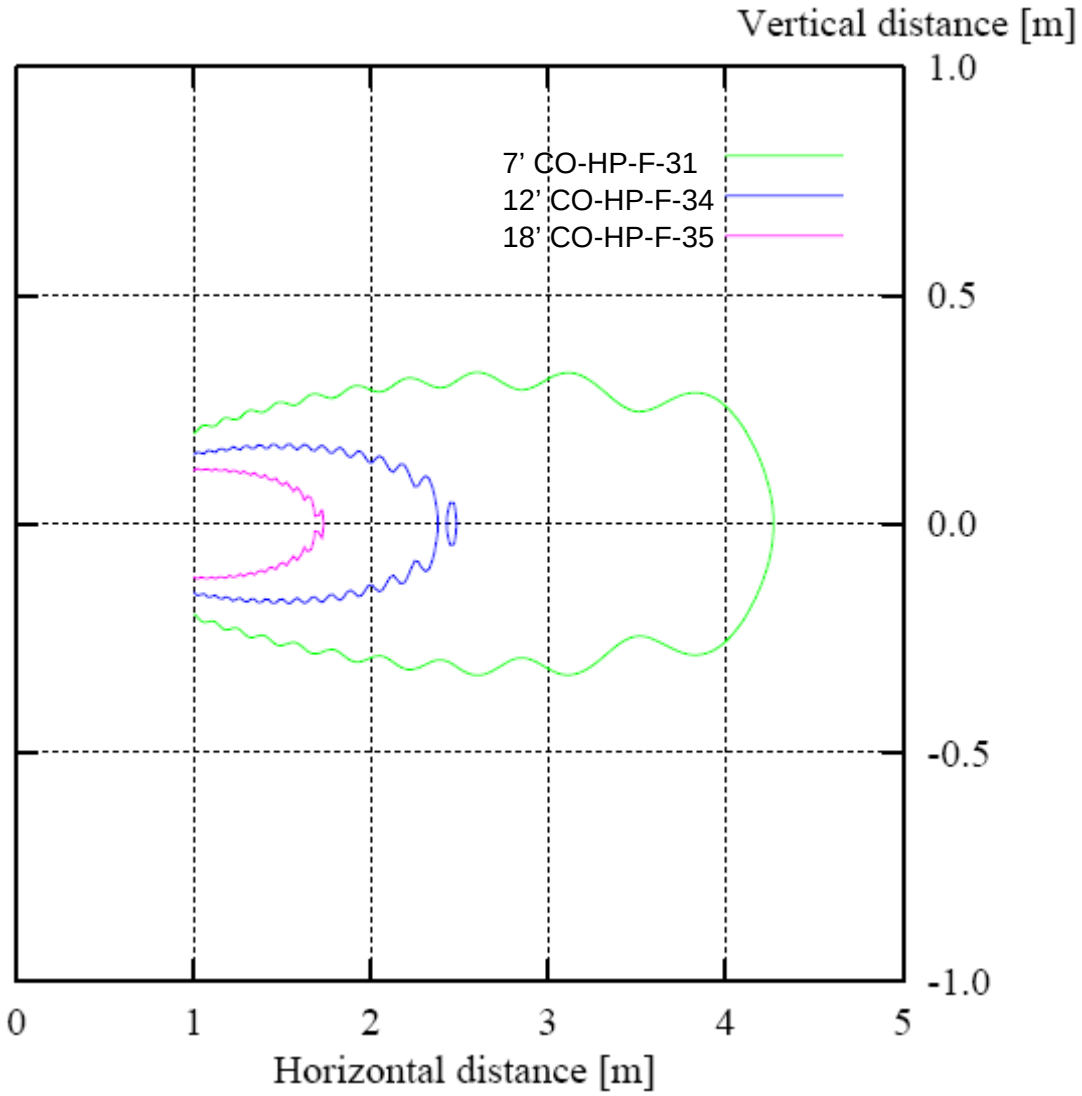

Figure 4 Power densities of 100W/m^2 (= 10dBm/cm^2) for Compact antennas, 200W peak power, non-rotating

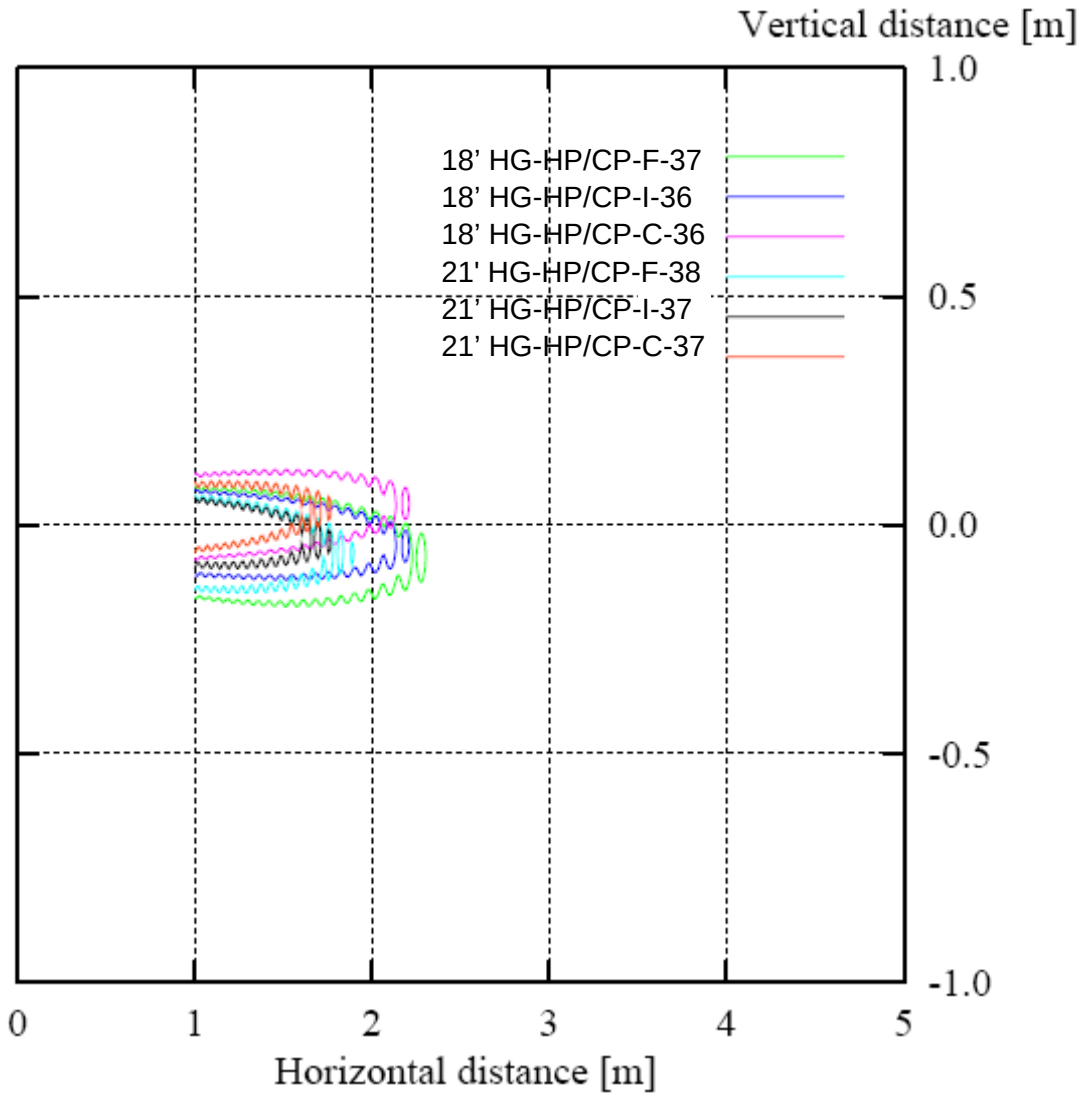

Figure 5 Power densities of 100W/m^2 (= 10dBm/cm^2) for High Gain antennas, 200W peak power, non-rotating

5.2 Additional remarks

Additional safety margins in respect to microwave radiation can be obtained by increasing distances to the radiating antennas.

As a rule of thumb, the power density is inversely proportional to the square of the distance from the radiating source. Thus, increasing the distance with a factor of 10 will reduce the power density with a factor of 100.

However, this is only true in the far fields distance. Complex calculations for the region near the antennas show that:

- Power density is a factor of at least 10 times below the ICNIRP recommendations for general public for all locations 1 meter or further below the antenna and at any position beyond 5 meter horizontal distance.
- Power density is a factor of at least 10000 times below the ICNIRP recommendations for general public for all locations 30 meters or further below the antenna.

Furthermore, sector transmission is normally implemented, stopping transmission for the parts of the antenna rotation not covering the sea surface. Furthermore, power sectors can be defined in which the transmitted power is reduced.

For additional safety, SCANTER 5000 and 6000 series transmitters are closed down when antenna rotation is stopped. However, transmission into a stopped antenna can be tolerated without violating the ICNIRP recommendations for general public, for all locations 1 meter or further below the antenna or at any position beyond 7 meters horizontal distance.

Finally, for occupational staff, be aware of safety regulations for rotating machinery. Installations usually include a man-a-loft switch preventing transmission and preventing the antenna from rotating during service.